Outline of Selected Project

Host institution	Keio University
Center name	Human Biology-Microbiome-Quantum Research Center
Head of host institution	Kohei Itoh
Prospective Center director	Kenya Honda

＜Project Summary＞

Human homeostasis is maintained through complex interactions between multiple organs, and its disruption causes a wide range of diseases. Our center aims to understand how humans process external information and maintain homeostasis by dispersing and integrating signals among cells/organs. We will investigate how homeostasis and human biology are regulated by the epithelial, immune, nervous, and metabolic systems, with an emphasis on the microbiome, an important factor that remains one of the "black boxes" of the human body. Our center will thus establish a new form of life science aimed at understanding human multiorgan homeodynamics at resolutions higher than those achieved so far. We will implement quantum computing together with artificial intelligence (AI) to analyze the collected multiomics data and elucidate the multiorgan interaction pathways underlying human disease. Furthermore, we will also establish a reverse-translation workflow to decipher the causal relationships within the newly uncovered pathways.

The Human **Bio**logy-Micro**bio**me-**Q**uantum Research Center, namely the "Bio2Q", will develop state-of-the-art technologies in microbiome analysis, metabolomics, connectomics, organoids, humanized animal models, and in situ structural analysis. We will also establish new methods of applying quantum computers to biology, thereby forging an interdisciplinary research area that will lead to groundbreaking progress in elucidating the regulatory mechanisms of human homeostasis. In the long term, we will develop new prophylactic/therapeutic approaches to promote healthy longevity.

<Remarks>

1. This is a challenging proposal aiming to clarify the linkage between intestinal microbiome and various organs and their relationship to diseases by using computational science, especially pioneering the application of quantum computing to speed up the multi-omics data analyses, which are of great importance today.
2. The proposed director is one of the top leaders in the field of microbiome, and the researchers in the field of each organ are also leaders in their respective fields. The host institute,

Keio University, is one of the front runners in quantum computing research in Japan. The synergistic effects of these groups will work well to achieve the goal of the project.

3. The host institution has committed strong support to the center in terms of infrastructure, personnel and funding. The center is aligned to the strategic vision for the future of the host institution.

Keio University — Human Biology-Microbiome-Quantum Research Center (Bio2Q)

Center Director
Kenya Honda

Kenya Honda has innovated microbiome analysis by integrating germ-free animal models, anaerobic bacterial culture, and metagenomic studies and has made seminal contributions to elucidating the role of the microbiome in inflammatory diseases and cancer. The Bio2Q center will collect data on how multiple organs and the microbiome interact in disease, development, and aging, and it will use artificial intelligence and quantum computing to develop a new life science that will help us better understand human health.

Mission

Human health is maintained by complex interactions between multiple organs. These interactions include the microbiome, which exists on every external surface of the body, and the resulting information is processed and utilized in a coordinated manner.

Our center will develop novel research techniques to understand the interactions between multiple organs and the microbiome and develop methods to apply quantum computing to human biology. Our mission is to forge a new interdisciplinary research area that will lead to groundbreaking progress in elucidating the regulatory mechanisms sustaining human health. In the long term, we will develop new prophylactic/therapeutic approaches to promote healthy longevity.

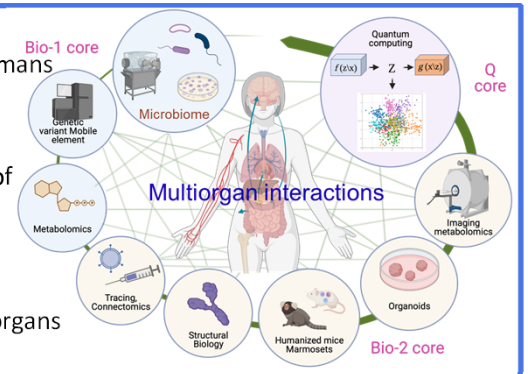
Identities

- World leaders in microbiome research, organoid technology, metabolic analysis, neural circuit analysis, and quantum computing
- Integration of cutting-edge technologies of the three research core units, the Multidimensional data analysis core, the Homeodynamics mechanistic analysis core, and the Quantum computing core, to promote fusion research
- Application of Artificial Intelligence (AI) and quantum computing to further the understanding of human biology
- Comprehensive, longitudinal clinical samples related to cancer, diabetes, obesity, neuropsychiatric disorders, developmental disorders, immune disorders, aging, and centenarians
- A joint cross-disciplinary graduate English program between the Graduate School of Medicine, Graduate School of Pharmaceutical Sciences, and Graduate School of Science and Technology (STaMP)

STaMP program
(Science and Technology, and Medicine, Pharmacy)

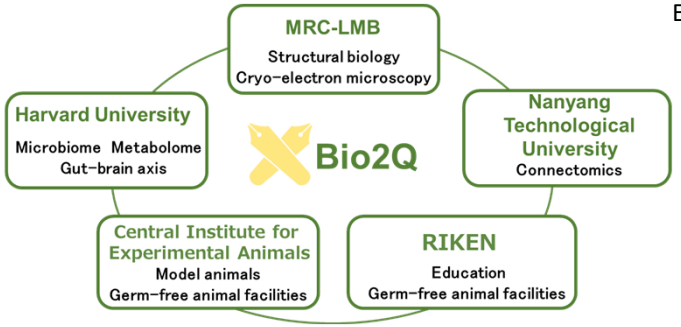
Research

Microbiome: the collection of all microbes within an ecosystem



1. Accumulate multiomics data from humans and model organisms and compile a multidimensional database.
2. Elucidate the structure and function of microbiome-derived metabolites.
3. Refine imaging metabolomics and structural biology to promote in situ functional analysis of metabolites in organs and cells.
4. Develop quantum computing-based algorithms and pipelines to analyze the interactions between multiple organs and microorganisms.
5. Model the interface between the environment and the human body by advancing organoid technology and animal models and elucidate the mechanisms underlying the conversion of external factors into internal signals.
6. Leverage connectomics and structural biology to understand the dynamic multiorgan interactions, including gut-brain communication.

Collaborations



Exchange of researchers, knowledge, data, samples, and expertise

Scientific excellence

New cross-disciplinary paradigms